Evaluation of the addition tourniquet and ultrasound application to axillary block success, reliability and patient satisfaction

Ultrasonography and tourniquet application to axillary block

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Abstract

Aim: The purpose of this study was to evaluate axillary brachial plexus blockade with ultrasonography and peripheral nerve stimulator guidance and the effect of tourniquet addition to multi and single injection.

Material and Methods: We randomly allocated 60 patients undergoing hand surgery to the following groups: Group 1 (single tourniquet multi-injection; a rubber tourniquet was applied 8 cm below the nerve stimulator needle entrance area before blockade), Group 2 (double tourniquet single injection; the distal tourniquet was applied in the same way, and a second tourniquet was applied 2 cm above the injection site just after the removal of the nerve stimulator needle), and Group 3 (double tourniquet multi-injection; both tourniquets were applied and axillary block was performed with multi-injection). The same local anesthetic agent was used in all patients. The success rate, the onset of blockade, and patient satisfaction were evaluated.

Results: The success rate was 100% in all groups. The blockade duration was shorter in Group 2. Patient satisfaction was the lowest in Group 3 and the highest in Group 2.

Discussion: Ultrasonography and peripheral nerve stimulator-guided axillary blockade accompanied by tourniquet application may result in better success rate and patient satisfaction and may be safer. Although the axillary block technique has been known and applied for a long time, we believe that it is a regional anesthesia technique, which is still open for innovations and further studies.

Keywords

Ultrasound; Tourniquet; Axillary block

Introduction

Axillary approach to the brachial plexus is commonly used in hand, wrist, and arm surgeries as it is a safe and easy method. [1] The purpose of this study was to evaluate the addition of tourniquet to multi and single injection techniques using the combination of ultrasonography and peripheral nerve stimulator in the axillary approach to the brachial plexus in terms of block success, reliability, and patient satisfaction.

Material and Methods

This study was carried out in 60 elective hand surgery cases in the operating room of the Department of Orthopedics and Traumatology of the A.Ü. Ibn-i Sina Hospital. Patients who underwent hand, forearm, wrist, and elbow surgery were included in the study. Patients with ASA (American Society of Anesthesiologists) class >2, severe cooperation problems, those younger than 18 years and older than 70 years, those with previously known allergies to local anesthetic agents, and those with infection at the injection site were excluded from the study. Patients with ASA class I-III were included in the study. Ethics committee permission was obtained from Ankara University and consent forms were obtained from the patients.

Study Groups

Envelopes with group names I, II, and III were prepared prior to the procedure. When the patients were transferred to the operating room, they were asked to select a random envelope with their own hand, and the axillary block procedure was performed using the technique mentioned in the envelope selected by the patient. The block procedure was performed by an anesthesiologist who was competent and experienced in regional anesthesia in the clinic. The blocks were evaluated by an anesthesiologist and a faculty member who were experienced in the field of peripheral nerve blocks and did not know to which group the patient was assigned. The number of patients for each group was calculated by NNT (numbers needed to treat).

Group 1: Axillary Block Group with Single Tourniquet Multi-Injection Technique

Group 2: Axillary Block Group with Double Tourniquet Single Injection Technique

Group 3: Axillary Block Group with Double Tourniquet Multi-Injection Technique

Patient Preparation and Positioning

Patients in all groups were placed in the supine position and brought to 90° abduction on the shoulder and 90° flexion and supination at the elbow on the arm. The patients were administered 0.04 mg/kg/IV midazolam as standard premedication. A 22-gauge, 5-cm-long Teflon-coated neurostimulator needle was used as a neurostimulator (Plexygon; Vygon). The nerve stimulator setting was set at a pulse duration of 0.15 ms, current intensity of 1 mA, and a frequency of 2 Hz. In the ultrasonography procedure (General Electric-Vivid), a 5-cm 8–13 MHz linear probe was used as the ultrasonography probe. A 30-mL solution consisting of 20 mL of 5% levobupivacaine and 10 mL of 2% lidocaine was used as the local anesthetic agent.

Axillary block technique

Group 1: single tourniquet multi-injection technique

Prior to the procedure, a rubber tourniquet was placed 8 cm below the area where the neurostimulator needle was planned to be inserted for all patients in this group. Following the induction of local anesthesia using 10 mL of a local anesthetic mixture injected into the sheath to block the radial nerve, 7 mL for the median nerve, 7 mL for the ulnar nerve, a nerve branch visible on the US screen was identified.

Group 2: double tourniquet single injection technique

After placing a rubber tourniquet 8 cm below the area where the injection was planned on the patient's arm, blockage was used based on the area where surgical intervention was planned with ultrasonography and stimulator. If the surgical intervention site was in the radial nerve region, blockage was used at the point that corresponded to the radial nerve, if the surgical intervention site was in the median nerve region, the blockage was used at the point that corresponded to the median nerve, and if the surgical intervention site was in the ulnar nerve region, blockage was used at the point that corresponded to the ulnar nerve. A total of 30 mL of local anesthetic agent was administered into the axillary sheath.

After the procedure, the neurostimulator needle was quickly removed, and another tourniquet was placed 2 cm above the intervention site. Due to the anatomy of the region, it was thought that the second tourniquet did not apply sufficient pressure, and more pressure was manually applied. This pressure was increased until the saturation probe attached to the finger of the treated arm did not scratch. We planned to increase the infiltration of the local anesthetic agent into the nerve by increasing the pressure in the area between the two tourniquets. These pressures were maintained for 2 minutes.

Group 3: double tourniquet multi-injection technique

Prior to the procedure, a rubber tourniquet was placed 8 cm below the area where the neurostimulator needle was planned to be inserted for all patients in this group. Axillary block procedure was performed as in Group 1, and then a double tourniquet procedure was performed as in Group 2.

For N. Musculocutaneus and intercostobrachial nerve blockage, 6 ml of the local anesthetic agent was administered similarly for single tourniquet and double tourniquet groups by visualizing the nerve in the coracobrachialis muscle. However, no additional block was applied to this nerve in the single injection group.

After the block was performed, the sensory block control was performed with the pinprick test, and motor functions were evaluated individually for each nerve. The onset time of the sensory block and the presence or absence of a motor block were recorded individually for each dermatome. Sedation was performed for each patient using 0.04 mg/kg/IV routine midazolam. In the postoperative follow-up, the hospitalization period of the patients in all groups, and the patient and physician satisfaction during discharge were questioned. One week after discharge, the patients were contacted via phone in order to determine whether they experienced paresthesia in the arms where the block was performed.

Results

Patients in all groups were compared in terms of demographic data. The distribution of the patients among the groups was statistically similar when compared in terms of age, weight, height, and arm diameter (Table 1).

Table 1. Distribution of patients by groups

	G1 (n: 19) Median (Min–Max)	G2 (n: 20) Median (Min– Max)	G3 (n: 21) Median (Min–Max)	P Value
Age (years)	35 (19–59)	50.5 (18–77)	38 (21–89)	0.412
Weight (Kg)	75 (48–110)	79 (52–95)	73 (58–105)	0.847
Height (cm)	173 (160–183)	170 (155–185)	170 (155–185)	0.735
Arm diameter (cm)	31 (24–48)	32 (25–40)	32 (24–60)	0.228

In this study, the axillary block procedure was performed using three different techniques that were assigned to the study groups. The block formation time was examined, and the median value was 5 minutes (2 min – 28 min) for patients in Group 1, 3 minutes (1 min – 5 min) for patients in Group 2 and 4 minutes (2 min – 7 min) for patients in Group 3. As a result, it was observed that this time was statistically significantly shorter in Group 2 compared to the other two groups (p-value <0.001).

Peripheral Nerve Block Formation Times

In the evaluation of the formation time of sensory and motor blocks of the radial nerve in the patients, there was no significant difference between the groups (Kruskal–Wallis Test). However, it was observed that the motor block was formed more rapidly in Group 3 (Table 2).

In the evaluation of the sensory and motor block formation time of the median nerve in all patients, there was no significant difference between the groups (Kruskal–Wallis test). However, similarly, it was observed that sensory and motor blocks were formed clinically more rapidly in Group 3 (Table 2).

In the evaluation of the sensory and motor block formation time of the ulnar nerve in all patients in all three groups, there was no significant difference between the groups (Kruskal–Wallis test). However, it was observed that sensory and motor blocks were formed more rapidly in group 3 (Table 2).

In the evaluation of the sensory and motor block formation time of the musculocutaneous nerve in all patients in all three groups, there was no significant difference between the groups (Kruskal–Wallis test). In Group 3, it was observed that sensory and motor blocks were formed more rapidly in Group 3 (Table 2).

Based on the examination of the patients in all groups in terms of the presence of comorbidities, 39 out of 60 patients did not have comorbidities, while 21 had comorbidities. In this case, the rate of patients with comorbidities was 65%, out of which 42.9% had multiple diseases. The distribution of the comorbidities between the groups was examined by the Chi-square test, and the resulting p-value of 0.224 was not considered significant (p >0.005).

The Mann–Whitney U test was used to examine whether there was a relationship between comorbidities and block formation time. No relationship was found between the presence of comorbidity and block formation time.

Patient and physician satisfaction was evaluated. The satisfaction levels of the patients and the physician regarding the block formed were classified into 3 groups as follows: very satisfied, satisfied, less satisfied. The result was not statistically significant. However, based on the examination of the results, Group 3 was the worst group in terms of patient satisfaction, and Group 2 was the best group (Table 3).

Table 2. Block formation times

Parameter	Group 1 Median value for block time (min–max)	Group 2 Median value for block time (min–max)	Group 3 Median value for block time (min–max)	P
Radial Sensory	4 minutes (1–15)	3 minutes (1–15)	3 minutes (1–15)	0.300
Radial Motor	7 minutes (3–25)	5.5 minutes (1–17)	5 minutes (2–11)	0.392
Ulnar Sensory	2 minutes (1–7)	3 minutes (1–8)	2 minutes (1–5)	0.173
Ulnar Motor	7 minutes (2–13)	5.5 minutes (2–19)	5 minutes (2–9)	0.224
Median Sensory	4 minutes (1–15)	4 minutes (1–9)	3 minutes (1–9)	0.470
Median Motor	7 minutes (2–25)	7.5 minutes (3–17)	5 minutes (2–11)	0.152
Musculocutaneous Sensory	3 minutes (1–8)	4 minutes (1–10)	3 minutes (1–8)	0.097
Musculocutaneous Motor	8 minutes (1–26)	6.5 minutes (3–16)	5 minutes (2–12)	0.129

Table 3. Patient and physician satisfaction in all groups

	Group 1	Group 2	Group 3	P
Patient	Very satisfied 94.7%	Very satisfied 100%	Very satisfied 85.7%	0.184
Physician	100% effective	100% effective	100% effective	1000

Since the block procedures were successful in all groups, they were all accepted as sufficient and effective by the physicians. Patients who could not attend the control visit were contacted by phone in one week in order to ask whether they had paresthesia. Paresthesia was evaluated at the orthopedic clinic in those who attended the control visit. None of the patients had paresthesia.

Discussion

During the axillary approach to the brachial plexus, plexus detection techniques include loss of resistance technique, facial click technique, paresthesia technique, nerve stimulation technique, and ultrasonography technique, which has been increasingly used recently [2]. In the anatomical structure of the brachial plexus, the idea that the vascular nerve bundle is in a sheath, namely the "perivascular sheath theory", was first developed by Winnnie et al. [3]. As in the article by Cornish Philip et al., it has recently been recognized that this anatomical structure encircles and protects the important structures here [4]. Anatomically, many methods have been tried to prevent septa of the brachial plexus from interfering with block success. In 1961, De Jong attempted to provide maximal anesthesia by administering 40–50 mL of local anesthetic agent to this space [5]. In 1977, Selender tried to overcome this problem by inserting a catheter [6]. In 1983, Thompson and Rorie argued that the axillary sheath consisted of multiple compartments, that each nerve was surrounded by a sheath, and that this problem could be overcome with small doses of multiple injections [7]. In 1986, Vester-Anderson et al. showed that there was spread to other compartments by injecting gelatin into the axillary sheath in cadavers [8]. Partidge et al. put forward the idea of a single compartment in 1987 and stated that the axillary sheath consisted of multiple pseudo-fascia membranes, that the injected solution easily reached the nerves through this weak perivascular connective tissue, and that multiple injections would be unnecessary [9]. In this context, Cockings et al. reported a 99% success rate in forming axillary blocks

using a single injection technique in 1987 [10]. In this study, the researchers used 50 mL of local anesthetic agent. In our study, the success rate was 100% in Group 2, in which we used 30 mL of local anesthetic agent and double tourniquet single injection technique. In 1999, a study was conducted by Zbigniew J. Koscielniak - Neilsien et al. on 106 patients, in this study, the block application time was 11 (6–15) minutes in the multi-injection group and 7 (5–13) minutes in the single injection group [11]. We agree with the researchers' opinion and think that the use of ultrasonography will increase the chance of injecting into the compartments that form the axillary sheath. We also think that increasing the pressure through the tourniquet will allow passage through these neural structures. We think that we have proven this by showing that the double tourniquet single injection groups are as successful as the other groups.

ZJ Koschielniak-Nielsen et al. examined whether applying pressure from the distal and bringing the patient's arm to adduction could facilitate the spread of the local anesthetic agent to the distal. They concluded that pressure from the distal prevented the spread of the local anesthetic agent to the distal, but this did not increase the spread of the local anesthetic agent to the proximal, that applying pressure did not increase the success rate of perivascular block, and that applying pressure had no clinical significance [12].

The low cost and ease of application of PSS devices has increased the use of neurostimulators. However, the minimum current of milliamperes (mA) that is required for nerve localization with PSS devices is still controversial, and the question "Is there an optimal stimulation current?" is still being discussed [13].

It is recommended to achieve a motor response with a current equal to or less than 0.5 mA before injecting a local anesthetic agent. It is believed that block success rate will increase as the distance between the nerve and the needle tip decreases in localizations below 0.5 mA [14].

The first attempt to apply an ultrasound-guided block was carried out by La Grange et al. in 1978 [15]. Later, in parallel with the development of the ultrasound device, the image quality increased, and the nerve imaging with ultrasound became a common technique. The first important description of this was made by Kapral in 1994 [16].

Casati et al. in 2007, used the multi-injection technique and investigated whether the use of ultrasonography shortened the block formation time and demonstrated that the success rates of ultrasonography and neurostimulator technique were similar for experienced specialists 17].

The Cochrane group, which is still in the study process of evaluating ultrasonography-guided blocks, defined the characteristics sought in prospective, randomized, controlled peripheral nerve blockade studies in this scientific field [18].

Another important discussion subject is that the median value for the block formation time in Group 2, i.e., double tourniquet single injection group, was calculated as 2 min (1–5) (p < 0.001), and while it was shorter compared to the other groups, the block formation time was clinically shorter in Group 3, i.e., double tourniquet multi-injection group, although not statistically significant. In our study, it was observed that sensory and motor block of musculocutaneous nerve was achieved most rapidly in

Group 3, that is, in the double tourniquet multi-injection group. Similarly, shorter sensory block formation times were achieved in Groups 1 and 3, which was an interesting result. It can be concluded that in Group 3, the local anesthetic agent transitioned into N. Musculocutaneus more rapidly in multiple injections. In this context, the increase in the number of injections, rather than the increase in the number of tourniquets, accelerated the block formation time even more. The formation of the most rapid motor block in Group 3 suggests that the infiltration of local anesthetic agent into the motor fibers also increased as a result of the increased pressure in the region with the double tourniquet.

In our opinion, the short duration of block formation in Group 2 is the result of performing a single injection in this group, which can be considered as a very important advantage in maintaining the circulation of the operation room, and this technique may be preferred in practice.

Of the 662 patients for whom Nick et al. applied axillary block, they used US for 535 patients and conventional techniques for 127 patients. The duration of stay in the block room for those with US-guided blocks was 30.64 + 14.2 minutes, while it was longer (40.1+ 27.3 minutes) for those who underwent block procedure using conventional methods (p < 0.0001) [20].

In our study, there was no significant difference in the quantity of additional midazolam and opioids required after the block was created between the patient groups. Additional midazolam and opioids were not used as rescue medicines. Considering these studies, it has been reported that 50–100 mcg of fentanyl is not sufficient to ensure analgesia [21].

In our study, patient and physician satisfaction was also evaluated. Patient satisfaction level was the lowest in Group 3, although not statistically significant (85.7%). It was thought that the application of both multiple injections and double tourniquets led to this lowered satisfaction level of the patients in this group.

On the other hand, the patient satisfaction level in the double tourniquet single injection group (Group 2) was 100%; in the light of this, it was thought that the number of injections was considered to be a greater cause of discomfort for the patients compared to the use of a double tourniquet. Although there seems to be a difference of 2 injections between Group 2 and Group 3, withdrawing the needle for searching new directions increases this number significantly.

Conclusion

The primary result of this study is that 100% successful axillary block was obtained with ultrasound and PSS in addition to 30 mL of local anesthetic volume and tourniquet application. We believe that the most advantageous technique is the one used in Group 2. The most important reason for this is that the patient satisfaction level is 100%, the block formation time is short, and the circulation in the operation room is not restricted. In addition, it is noted that increasing the pressure of the axillary area with a double tourniquet clinically shortens the time required to block the nerves in this region. On the other hand, an increase in the number of injections with double tourniquet leads to complications such as methemoglobinemia. Although the duration of sensory and motor block of target nerves in the double tourniquet multi-injection group is clinically shorter than

in the other groups, it is necessary to increase the number of patients to achieve definite results.

Although the axillary block technique has been known and applied for a long time, we believe that it is a regional anesthesia technique, which is still open for innovations and further studies.

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